Title	Reply to comments of Nordman and Weiland on Norton et al. On "ion-temperature-gradient-driven transport in a density modification experiment on the Tokamak Fusion Test Reactor" [Phys. Fluids B 4, 953 (1992)] [1]
Author(s)	Horton, W.; Lindberg, D.; Kim, J. Y. et al.
Citation	Physics of Fluids B. 5(3) p.1034-p.1035
Issue Date	1993-03
oaire:version	VoR
URL	https://hdl.handle.net/11094/78511
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Note	

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Cite as: Physics of Fluids B: Plasma Physics **5**, 1034 (1993); https://doi.org/10.1063/1.860508
Submitted: 27 August 1992 . Accepted: 05 November 1992 . Published Online: 04 June 1998

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Reply to comments of Nordman and Weiland on Horton *et al.* on "Ion-temperature-gradient-driven transport in a density modification experiment on the Tokamak Fusion Test Reactor" [Phys. Fluids B 4, 953 (1992)]

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(Received 27 August 1992; accepted 5 November 1992)

Here, we discuss the comments by Nordman and Weiland[1] regarding our comparison in Ref. 2 with their studies[3,4] of η_i mode stability and transport. First, we would like to point out that in Ref. 2 there was a typographical error in the presentation of the solution from the fourth-order polynomial dispersion relation of the Swedish model. The normalized growth rate of the ion mode should be changed from 0.0537 to 0.537. This corrected value now agrees exactly with that given by Nordman and Weiland in their comments[1] if we take into account the different normalization. Also, with this value for the growth rate we find that the Swedish model gives $\chi_i/\chi_e \sim 4$, in agreement with the result stated in their comments.[1]

It appears, however, that the growth rate from the Swedish model is now much higher than our local kinetic value (~ 0.148). The large value of the growth rate (and of the real frequency) in the Swedish model is due to the effects of the trapped electrons which they included and the fluid approximation that they used. The fourth-order polynomial [Eq. (10) of Nordman *et al.*[3] which is also Eq. (1) of Nordman and Weiland[4]] describes the toroidal η_i mode, neglecting $k_\parallel v_i/\omega_D$ as explained in their comments,[1] and more importantly taking a similar hydrodynamic description for the electrons. In particular, the trapped electron fraction is taken as $f_t(r) = [2r/(R+r)]^{1/2}$, and only the passing or free electrons with fraction $1-f_t$ have an adiabatic response, while the trapped fraction $f_t(\sim 1/2)$ has their local toroidal response given by $1/N_e(\omega)$. This local trapped electron response differs appreciably from our bounce-averaged electron response [Eq. (19) of Ref. 2], which includes the energy and pitch angle integral over the bounce-averaged electron propagator $1/(\omega - \bar{\omega}_{De})$. As Nordman *et al.*[3] discuss in some detail between Eqs. (10) and (12) of Ref. 3, their model of the trapped electron response gives a collisionless trapped electron mode with characteristics similar to the hydrodynamic electron η_e mode of Horton *et al.*[5] It should be pointed out that Horton *et al.*[5] restricted consideration to short perpendicular wavelengths in order to guarantee hydrodynamic electron behavior, whereas Nordman *et al.*[3] obtained it through large $f_t(r)$ and their model for $N_e(\omega)$. A comment made in Ref. 2 and repeated here is that by solving the ballooning eigenmode equation we obtain the appropriate averaging of $\cos\theta$ and $s\theta \sin\theta$, whereas the formula of Nordman *et al.*[3] is equivalent to evaluating these toroidal drift terms at $\theta = 0$ (the outside of the torus). Basically, these differences in the treatment of the electron dynamics explain why a much stronger growth rate of the η_i mode was found in Ref. 3.

In their comments,[1] Nordman and Weiland also note that for a different kind of discharge, called a "hot-ion mode," they obtain $\chi_e/\chi_i \sim 4$. We did not analyze this "hot-ion mode" discharge in Ref. 2. In the following paragraphs, we make several observations concerning their comment on the L mode and the "hot-ion mode."

One problem is that the Chalmers groups may have misread the paper by Fonck *et al.*[6] which did not deal with the L-mode plasma but described the local transport in supershot and hot-ion mode plasmas. Hence, their claim that their model's prediction $\chi_e/\chi_i \sim 1/2$ for typical L modes with $T_e \sim T_i$ is in agreement with TFTR (Tokamak Fusion Test Reactor) data is pointing to the wrong regime. The correct statement is that $\chi_i/\chi_e = 3$–4 in the L-mode regime (see, for example, Figs. 2 and 6 in Ref. 7; Fig. 4 in Ref. 8, which has a range of ratios of χ_i/χ_e ranging from 1 to 5, with almost all of the values in the range 2–5, and a rough mean value of 3; Figs. 1 and 3 in Ref. 9 which show that χ_i/χ_e goes to ~ 4 in the broad density profile L-mode regime; Fig. 1 in Ref. 10 which shows $\chi_i/\chi_e \sim 4$ at $r/a = 0.5$ during a supershot to L-mode transition experiment; and finally, see Ref. 11 which gives a plot of χ_i and χ_e versus radius for different powers in a constant-density beam power scan—here the ratio between χ_i and χ_e is quite large, perhaps a factor of 5 or so).

The statement that their model predicts $\chi_e/\chi_i \sim 4$, which they claim to be in agreement with TFTR's hot-ion mode ($T_e/T_i \sim 0.2$) with broad density profiles, is also unclear. First, the hot-ion regime has peaked density profiles, irrespective of whether true supershots or unbalanced supershots are considered—both have $n_e(r)$ considerably more peaked than the L-mode regime. Second, at the half-radius in supershots $\chi_e \leqslant \chi_i$ is typically observed (see Figs. 1 and 3 in Ref. 9).

There is an unfortunate diversity of definitions for the "hot" regime. Sometimes it is used to refer to any low-recycling regime that achieves high ion temperatures and confinement in excess of L mode, irrespective of the beam directionality (balanced or unidirectional). On the other hand, Ref. 8 tried to differentiate between a true supershot, which has balanced injection, T_i up to ~ 30 keV, peaked density profiles, and $\tau_e \sim 3$ L mode, from a "hot-ion" mode, which has unidirectional injection, $T_i \leqslant 20$ keV, less peaked density profiles, and typically τ_e only twice the L mode. Under this definition, Ref. 12 shows that in the hot-mode regime, the value of χ_i/χ_e ranges from 0.8 to 2.5 over the confinement region $(0.3 < r/a < 0.8)$. Thus, there are no qualitative differences in the value of the ratio χ_i/χ_e between the hot-ion mode and the supershot, whereas the ratio rises from 3 to 4 in L-mode plasmas (all at half-radius).

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